

## **The Stones of Science: Charles Harriot Smith and the importance of geology in architecture, 1834-1864**

In *The Stones of Venice* England's leading art critic, John Ruskin (1819-1900), made explicit the importance of geological knowledge for architecture. Clearly an architect's choice of stone was central to the character of a building, but Ruskin used the composition of rock to help define the nature of the Gothic style. He invoked a powerful geological analogy which he believed would have resonance with his readers, explaining how the Gothic character could be submitted to analysis, 'just as the rough mineral is submitted to that of the chemist'. Like geological minerals, Ruskin asserted that the Gothic was not pure, but composed of several elements. Elaborating on this chemical analogy, he observed that, 'in defining a mineral by its constituent parts, it is not one nor another of them, that can make up the mineral, but the union of all: for instance, it is neither in charcoal, nor in oxygen, nor in lime, that there is the making of chalk, but in the combination of all three'.<sup>1</sup> Ruskin concluded that the same was true for the Gothic; the style was a union of specific elements, such as naturalism (the love of nature) and grotesqueness (the use of disturbing imagination).<sup>2</sup> Ruskin's analogy between moral elements in architecture and chemical elements in geology was not just rhetorical. His choice to use geology in connection with architecture was part of a growing consensus that the two disciplines were fundamentally linked.

In early-Victorian Britain, the study of geology invoked radically new ways of conceptualizing the earth's history. Charles Lyell's *Principles of Geology* (1830-1833) argued that the earth's form was best examined by studying geological activity, such as volcanoes, earthquakes, and erosion.<sup>3</sup> Others, like the Oxford cleric and geologist William Buckland (1784-1856), rejected this emphasis on examining natural phenomena, and instead promoted geology as a subject best studied through fossil collecting and the observation of the earth's strata layout.<sup>4</sup> Despite these differences over what was the correct approach to investigating geology, the investigation of the earth was becoming increasingly intimate with the

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<sup>1</sup> John Ruskin, *The Stones of Venice, Volume II: The Sea-Stories*, in E. J. Cook and Alexander Wedderburn (eds.), *The Works of John Ruskin, Vol. X*, (London, 1904), pp. 182-3.

<sup>2</sup> Ibid., p. 183.

<sup>3</sup> Martin Rudwick, 'Lyell, Sir Charles, first baronet (1797-1875)', *Oxford Dictionary of National Biography*, Oxford University Press, 2004; online edn, May 2012 [<http://ezproxy.ouls.ox.ac.uk:2204/view/article/17243>, accessed 23 Aug 2014]; Martin J. S. Rudwick, *Worlds Before Adam: the Reconstruction of Geohistory in the Age of Reform*, (Chicago, 2008), p. 553.

<sup>4</sup> Neville Haile, 'Buckland, William (1784-1856)', *Oxford Dictionary of National Biography*, Oxford University Press, 2004; online edn, Oct 2007 [<http://ezproxy.ouls.ox.ac.uk:2204/view/article/3859>, accessed 23 Aug 2014].

construction of architecture. Geology involved new ways of analysing the composition of stone, and changing perceptions of how various rock types were formed. These understandings shaped unfamiliar ways of seeing building materials and approaching architecture.

Nowhere was this mid-nineteenth-century relationship between geology and architecture more apparent than in the works of the stone-mason and builder, Charles Harriot Smith (1792-1864). Working alongside geologists Henry De la Beche and William Smith on a national survey to select stone for Parliament, Charles Smith experienced geological practices of observing and collecting stone, which shaped his conception of architecture. He spent the following two decades promoting geological knowledge for architectural work. He advocated the scientific study of stone as integral to designing and constructing buildings. Practices which were at the heart of studying geology, Smith asserted, could be transferred to architectural endeavours. Yet while geology itself was a divided subject, with Lyell's focus on present-day phenomena contrasting to alternate approaches stressing the importance of observation and collection, Smith avoided such distinctions. Both forms of geology appeared relevant in Smith's work. Collecting, observing, and analysing, all provided techniques to help understand and choose building stone, while the study of contemporary geological activity shaped his conceptualization of the landscape and materials around him. The relationship between geology and architecture was contingent on interpretations of contemporary scientific works. The Victorian connection between science and architecture was constructed through social networks and readings of geological texts.

Within early-Victorian society, knowledge of rock types and their ordering in the earth's strata was considered to have practical applications for daily life.<sup>5</sup> Britain's economic expansion was built on iron and coal, and the locating of these raw materials was a crucial concern for an increasingly industrialized society. The ability to determine areas with coal deposits was a valuable geological promise. The identification of rock types was connected to the location of other important minerals. Perhaps the most celebrated application of geological knowledge to mineralogical exploitation occurred in the 1840s when geologist Roderick Murchison (1792-1871) predicted the location of gold deposits in Australia,

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<sup>5</sup> James A. Secord, 'The Geological Survey of Great Britain as a Research School, 1839-1855', *History of Science*, 24:3 (Sep., 1986), pp. 223-75, 223.

based on the examination of stone samples returned to Britain.<sup>6</sup> Gold was subsequently discovered in the 1850s, apparently proving geology's economic value. Despite this, much of geology's early promise remained unfulfilled. Locating coal was problematic due to red sandstones of differing ages, often seemingly identical mineralogically, appearing both above and below coal seams.<sup>7</sup> Nevertheless geology's utility remained celebrated.

Michael Hall and Carla Yanni's analysis of nineteenth-century architecture and the study of nature shows how the relationship between geology and architecture fits within this context. When the Museum of Economic Geology in London opened in 1851, it embodied the value of geological knowledge in industrial society. With the political support of Prime Minister Robert Peel, architect James Pennethorne (1801-1871) worked alongside De la Beche to construct a building which exhibited stone didactically. On the museum's second floor there was an exhibition of different coal types, while on the first floor, there were examples of iron ore on display. In place on the building's exterior, there were building stone samples, and on the ground floor there were specimens of varying stones which could be used in architecture.<sup>8</sup> Pennethorne and De la Beche used marbles for the entrance hall, magnesian-limestone for the façade, and decorated the interior walls with Scottish granites and Irish Serpentine.<sup>9</sup> This inclusion of displays emphasizing geology's role in architecture, in London's foremost museum promoting the science's economic value, was important. It shows how, as much as knowledge of coal and mineral resources, claims of advancing architecture were central to stressing geology's economic value. Geology was constructed as enhancing knowledge of the materials of industrialization, with improved architecture a valuable promise of such claims. Yanni has shown how in Victorian Britain, scientific ideas took shape through architectural works. The study of the earth's history and the evolution of different animal species was directly comparable to the study of architecture and the development of

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<sup>6</sup> Ben Marsden and Crosbie Smith, *Engineering Empires: a cultural history of technology in nineteenth-century Britain*, (Basingstoke, 2005), p. 38.

<sup>7</sup> Jack Morrell, 'Economic and ornamental geology: the Geological and Polytechnic Society of the West Riding of Yorkshire, 1837-53', in Ian Inkster and Jack Morrell (eds.), *Metropolis and Province: science in British culture, 1780-1850*, (London, 1983), pp. 231-56, 248; Martin J. S. Rudwick, *The Great Devonian Controversy: the shaping of scientific knowledge among gentlemanly specialists*, (Chicago, 1985); explained in Charles Lyell, *Elements of Geology*, (London, 1838), p. 406.

<sup>8</sup> British Geological Survey Archives, Keyworth (BGS) GSM/DC/A/C/1, 'Letter from R. Phillips to Henry De la Beche', (22 October, 1839), pp. 106-8, 107; to compare with the layout of the Oxford University Museum of Natural History in the 1850s, see Carla Yanni, *Nature's Museums: Victorian science and the architecture of display*, (Baltimore, 1999), pp. 62-90.

<sup>9</sup> Geoffrey Tyack, *Sir James Pennethorne and the making of Victorian London*, (Cambridge, 1992), pp. 179-91.

different styles.<sup>10</sup> Architectural styles were understood to become increasingly complex over time, while buildings were analogous to natural structures.

Michael Hall shows how, in relation to mid-Victorian Anglican Church architecture, geology provided architects with powerful metaphors which guided new approaches to building. Ruskin, himself a student of Buckland's while at Oxford University, suggested architects use geological examples from nature in their buildings, by decorating walls with different bands of colour.<sup>11</sup> This would be suggestive of the earth's strata, with buildings displaying their growth, or age, through layers.<sup>12</sup> Architects would thus be using their art to convey truthful statements about nature: in this case recent findings from geological investigations. Ruskin's idea was that the beauty of a building could come from its imitation of God's nature. William Butterfield (1814-1900) was at the forefront of transforming Ruskin's teachings into physical buildings. Butterfield employed polychrome brickwork in his most prominent projects, including Keble and Balliol Colleges in Oxford.<sup>13</sup> **(Image 1)** At All Saints' Church at Babbacombe, in Devon, Butterfield paid particular attention to stone, with red and grey sandstones banded like strata composing the walls, and highly polished rock samples add both external colour and instruction on the diversity of nature.<sup>14</sup> **(Images 2 and 3)** Butterfield's interest in geology, especially in relation to his Anglican notions of Creation, was reflected in his careful selection of stone in all his works, including the use of polished marble containing fossils for interior decoration.<sup>15</sup> Likewise George Frederick Bodley's (1827-1907) use of random bandings of red and white sandstones on St John the Baptist's Church at Tuebrook was evocative of nature. While the church's interior implied heavenly Jerusalem, its exterior

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<sup>10</sup> Carla Yanni, 'Development and display: progressive evolution in British Victorian architecture and architectural theory', in Bernard Lightman and Bennett Zon (eds.), *Evolution and Victorian Culture*, (Cambridge, 2014), pp. 227-60, 229.

<sup>11</sup> On polychromy in architecture at this time, see Neil Jackson, 'Clarity or Camouflage? The development of constructional polychromy in the 1850s and early 1860s', *Architectural History*, Vol. 47 (2004), pp. 201-26.

<sup>12</sup> Michael Hall, 'What Do Victorian Churches Mean? Symbolism and Sacramentalism in Anglican Church Architecture, 1850-1870', *Journal of the Society of Architectural Historians*, Vol. 59, No. 1 (March, 2000), pp. 78-95, 82-3; also see Michael Hall, 'G. F. Bodley and the response to Ruskin in Ecclesiastical Architecture in the 1850s', in Rebecca Daniels and Geoff Brandwood (eds.), *Ruskin and Architecture*, (Reading, 2003), pp. 249-76; on nature, including geology, as a source of inspiration for European architecture, see Barry Bergdoll, 'Of Crystals, Cells, and Strata: Natural History and Debates on the Form of a New Architecture in the Nineteenth Century', *Architectural History*, Vol. 50 (2007), pp. 1-29.

<sup>13</sup> Rosemary Hill, 'Butterfield, William (1814-1900)', *Oxford Dictionary of National Biography*, Oxford University Press, 2004 [<http://www.oxforddnb.com/view/article/4228>, accessed 29 Nov 2014].

<sup>14</sup> Paul Thompson, *William Butterfield*, (London, 1971), p. 140.

<sup>15</sup> *Ibid.*, pp. 35 and 142; thanks to David Lewis for making me aware of Butterfield's work at Babbacombe.

demonstrated the presence of God in nature.<sup>16</sup> This use of layered stone, based on geological strata, implied religious notions of a divine unfolding plan. Architecture directly conveyed ideas about God's continuing presence in the process of evolution, vanquishing fears of a God absent from a mechanistic universe set in motion.<sup>17</sup>

No better example of this geological influence on architecture appeared than Thomas Deane and Benjamin Woodward's Oxford University Museum, built between 1855 and 1861; a project in which Ruskin provided much artistic advice and support, including a donation of £300 towards the building's naturalistic ornament.<sup>18</sup> The museum's internal column shafts were all constructed of varying polished stones from around the British Isles, presenting a physical catalogue of different rock types. **(Image 4)** The museum's first curator, John Phillips (1800-1874), personally oversaw this work, ensuring each column's stone type was clearly labelled so as to provide an educative function for visitors.<sup>19</sup> Interestingly, it was Phillip's uncle, William Smith, who provided Charles Smith with much geological knowledge and instruction when they investigated the nation's stone quarries together in 1838. While Phillips and Ruskin ensured the Oxford University Museum was a place where different stone could be physically examined, Phillip's uncle was part of wider efforts to produce a written guide for architects interested in the geological character of alternate building stones. William Whyte has noted that an architect's choice of stone could embody specific cultural values. For example, the completion of Alfred Waterhouse's (1830-1905) Manchester Town Hall, completed in 1877, was a celebrated local event, but the use of three different granites from England, Scotland, and Ireland for the building's three great staircases encouraged notions that the building's opening was also a national occasion.<sup>20</sup>

The links between nineteenth-century science, religion, and architecture have been clearly demonstrated. I build on this understanding by looking at the materials and practical skills of building

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<sup>16</sup> Michael Hall, *George Frederick Bodley: and the later Gothic Revival in Britain and America*, (New Haven, 2014), p. 144.

<sup>17</sup> Hall, 'What Do Victorian Churches Mean?', p. 82.

<sup>18</sup> Frederick O'Dwyer, *The Architecture of Deane and Woodward*, (Cork, 1997), p. 175; for details see Trevor Garnham, *Oxford Museum: Deane and Woodward*, (London, 1992); on Ruskin and the museum, see Eve Blau, *Ruskinian Gothic: the architecture of Deane and Woodward, 1845-1861*, (Princeton, 1982), pp. 48-81.

<sup>19</sup> Carla Yanni, *Nature's Museums: Victorian science and the architecture of display*, (London, 1999), p. 83; O'Dwyer, *The Architecture of Deane and Woodward*, p. 223-4.

<sup>20</sup> William Whyte, 'Building the nation in the town: architecture and identity in Britain', in William Whyte and Oliver Zimmer (eds.), *Nationalism and the Reshaping of Urban Communities in Europe, 1848-1914*, (Basingstoke, 2011), pp. 204-33, 206.

such architecture. It seems clear that Charles Smith's projection of geology's value was part of a wider culture in which nature and architecture became increasingly interconnected. His efforts were consistent with a mid-nineteenth-century frame of mind to treat architecture scientifically. Within this scientific view of architecture, attention to choosing stone was a particularly nineteenth-century phenomenon. Before the expansion of Britain's canal and rail networks, stone which architects usually employed was either local or that which could be transported by sea and river. Increased transport infrastructure meant that the selection of stone available to Victorian architects was increasingly extensive.<sup>21</sup> This paper begins by exploring how Charles Smith experienced geology. Geology's emphasis on field work meant that it was a subject not only to be learnt, but a discipline which could actively be experienced. Following the Palace of Westminster's destruction in the fire of 1834, the architect Charles Barry led a royal commission to select stone for the new Parliament. **(Image 5)** In 1838 this commission conducted a nation-wide survey, investigating the qualities of various building stones and examining their performance in existing architectural works. Smith was the commission's 'master-mason', offering insights into each stone's potential durability and qualities for carving. Yet along with Barry and Smith, the government appointed two men of geology: De la Beche and William Smith. This combination of architectural and geological experience was prominent in much of Charles Smith's later writings. After examining Smith's experiences on the tour, this paper looks at his writings in the years after the government survey. Smith's experiences on the 1838 stone commission shaped a new way of approaching buildings. Smith laboured to produce knowledge, using geological practices, which would guide architects. He published accounts of building stones, providing details of their chemical and physical characteristics. This paper concludes by analysing how Smith engaged with recent geological publications, including those of Buckland and Lyell, in conceptualizing building materials. Smith provides an example of how geology texts could be read and who was reading them, in the mid-nineteenth century.<sup>22</sup> New understandings of the earth's geological

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<sup>21</sup> G. K. Lott, 'The Development of the Victorian Stone Industry', *The English Stone Forum Conference*, (York, 15-17 Apr., 2005), pp. 44-56, 47-8; to compare how nineteenth-century canal and rail expansion shaped contrasting ecclesiastical architecture in Berkshire and North Hampshire, see J. R. L. Allen, *Building late churches in North Hampshire: a geological guide to their fabrics and decoration from the mid-eighteenth century to the First World War*, (Oxford, 2009), pp. 8-9; J. R. L. Allen, *Late churches and chapels in Berkshire: a geological perspective from the late eighteenth century to the First World War*, (Oxford, 2007), p. 6.

<sup>22</sup> On Victorian readership and science, see James A. Secord, *Victorian Sensation: the extraordinary publication, reception, and secret authorship of Vestiges of the Natural History of Creation*, (Chicago, 2000), pp. 2-5; to compare Smith's reading with engineer Isambard Kingdom Brunel's, see Ben Marsden, 'Re-reading Isambard Kingdom Brunel: engineering

history had ramifications for architecture. The nature of how rock formed, what it was, and the geological processes acting on the earth's surface, influenced Smith's way of seeing stone, cement, and the construction of architectural projects. This article demonstrates how the construction of geology as part of architecture, was contingent on experiences, practices, and readings of geological work. It suggests that to really understand Victorian architecture, we must look to quarries and recognize the importance contemporaries attached to knowing, selecting, working, and seeing stone.

## Experiencing Geology

Throughout 1835 Lord Melbourne's Whig ministry held a controversial competition to select an architect for the new Houses of Parliament. In 1836 Charles Barry was declared the winner for his Gothic designs which combined a richness of detail, drawn from the study of medieval buildings, with a romantic outline.<sup>23</sup> In this endeavour, Barry received precious help from the authority in Gothic art, Augustus Welby Pugin (1812-52).<sup>24</sup> Pugin added an artistic delicacy which strengthened Barry's competition entry. Their work promised a Parliament of intricate Gothic decoration and elaborate stone work. An early problem Barry encountered was one prevalent in architecture: what stone should Parliament be built of to defy decay throughout the ages? The Conservative leader Robert Peel, a patron of William Buckland, suggested to Barry that he establish an investigating royal commission to choose a stone for Parliament that was both practical to work and hard enough to resist London's deleterious atmosphere.<sup>25</sup> Barry proposed this idea to Lord Duncannon, First Commissioner of Woods and Forests, in July 1838. He recommended a tour of the nation's quarries and ancient structures, 'accompanied by two or three scientific persons eminent for their Geological, topographical, and practical knowledge'.<sup>26</sup> Barry was sure

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literature in the early nineteenth century', Ben Marsden, Hazel Hutchison, and Ralph O'Connor (eds.), *Uncommon Contexts: encounters between science and literature, 1800-1914*, (London, 2013), pp. 83-109.

<sup>23</sup> M. H. Port, 'The Houses of Parliament competition', M. H. Port (ed.), *The Houses of Parliament*, (New Haven, 1976), pp. 20-52; Alexandra Wedgwood, 'The New Palace of Westminster', in Christine Riding and Jacqueline Riding (eds.), *The Houses of Parliament: history, art, architecture*, (London, 2000), pp. 113-35, 116.

<sup>24</sup> Phoebe B. Stanton, 'Barry and Pugin: A collaboration', in Port (ed.), *The Houses of Parliament*, pp. 53-72; also see Benedict Read, 'Sculpture and the New Palace of Westminster', in Riding and Riding (eds.), *The Houses of Parliament*, pp. 253-68.

<sup>25</sup> M. H. Port, 'Problems of Building in the 1840s', in Port (ed.), *The Houses of Parliament*, pp. 97-141, 97.

<sup>26</sup> The National Archives, Kew (NA), Records of the Board of Works (WORK) 11/17/5/10, 'Letter from C. Barry to Her Majesty's Commissioners of Woods & Forests &c', (5 Jul., 1838).

that this commission would find a stone ‘pleasing in color, good in quality, and capable of resisting the blackening and decomposing effects of a London atmosphere’. The report transpiring from this selection would, Barry believed, ‘be useful not only on the present but in all future occasions in the erection of public works’.<sup>27</sup>

Barry’s first choice for the commission was Henry Thomas De la Beche (1796-1855), who Barry described as ‘a mineralogist and Geologist’ whose ‘eminence’ was beyond doubt.<sup>28</sup> During the 1830s De la Beche had already conducted government work, geologically colouring ordinance survey maps for Devon, Cornwall, and West Somerset.<sup>29</sup> Barry selected William Smith (1769-1839) as the tour’s second geological authority. Barry’s initial choice had been Smith’s nephew, John Phillips, then professor of geology at King’s College London and a leading figure in the foundation of the British Association for the Advancement of Science (BAAS) in 1831.<sup>30</sup> Phillips rejected Barry’s offer, instead recommending William Smith. Smith had already secured respect as a geologist for his theory of the earth’s strata. In 1815 he published a coloured map of England, highlighting the country’s varying rock types, in the ordered beds, or strata, in which they lay. What he proposed was that these various strata of rock could be identified by the unique fossils deposited within them.<sup>31</sup> With such an understanding, it became possible to map the nation’s strata in order of how it laid in the earth. Sixty-nine years old at the commencement of the tour, William Smith’s ‘previous knowledge of nearly all the building-stones and quarries in the kingdom’ provided the geological knowledge which Barry was keen to employ for Parliament.<sup>32</sup> With Barry as the commission’s architect, and De la Beche and William Smith serving as geological authorities, the fourth member of the tour was to be a ‘practical master mason’ who could make observations on the workable qualities of stone for carving, cutting, and sculpting. Barry chose Charles Harriot Smith to fill this role.

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<sup>27</sup> Ibid..

<sup>28</sup> Ibid..

<sup>29</sup> See Henry T. De la Beche, *Report on the Geology of Cornwall, Devon, and West Somerset*, (London, 1839); Paul J. McCartney, *Henry De la Beche: observations on an observer*, (Cardiff, 1977).

<sup>30</sup> Jack Morrell, *John Phillips and the Business of Victorian Science*, (Aldershot, 2005), pp. 162-3.

<sup>31</sup> John L. Morton, *Strata: the remarkable life story of William Smith, ‘the Father of English Geology’*, (Horsham, 2004), pp. 30-1.

<sup>32</sup> John Phillips, *Memoirs of William Smith, LL.D., Author of the ‘Map of the Strata of England and Wales’*, (London, 1844), p. 122.



The son of the monumental sculptor Joseph Smith, Charles Smith entered his father's business before exhibiting work at the Royal Academy in 1809 and attended the Royal Academy Schools from 1814.<sup>33</sup> Smith had a strong interest in geology, mineralogy, and chemistry, being particularly fascinated with building stones. In the years after the Parliamentary stone commission, Smith went on to carve the capital of Nelson's Column in 1850 and was elected a member of the Royal Institute of British Architects in 1855.<sup>34</sup> Recent work on Victorian sculpture has emphasized how closely associated the art was with philosophical inquiry.<sup>35</sup> Charles Smith was concerned with architecture, but he was first and foremost a sculptor. His reading of geological works dominated his later career. He was, as he himself put it, 'a strange mongrel of art, science, literature and business'.<sup>36</sup> His experience of geological practices on the tour was part of a life's commitment to combining architecture with the study of the earth. As one of Smith's workers recalled in his obituary in *The Builder*, 'he never grasped for money, but he did for knowledge which he held fast but nevertheless gave away abundantly'.<sup>37</sup>

Charles Smith and his three fellow Parliamentary commissioners met in Newcastle for the close of the 1838 BAAS meeting and spent late-August and September on tour. First from Newcastle to Edinburgh, then to Glasgow, Carlisle, York, Tadcaster, Doncaster, Derby, Lincoln, and Birmingham, the four men analysed ancient structures before examining the quarries from which the stone had been obtained.<sup>38</sup> All the while, samples of stone were collected from quarries which had produced enduring architectural structures. These buildings included the ruined St Mary's Abbey at York Museum, York Minster, Ripon Minster, several parish churches, and great country seats such as Castle Howard. After a three-day break in London, the survey resumed from 26 September until 5 October. This time the

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<sup>33</sup> E. I. Carlyle, 'Smith, Charles Harriot (1792–1864)', rev. M. A. Goodall, *Oxford Dictionary of National Biography*, Oxford University Press, 2004 [http://ezproxy.ouls.ox.ac.uk:2204/view/article/25787, accessed 31 Aug 2014].

<sup>34</sup> Rupert Gunnis, *Dictionary of British Sculptors, 1660-1851*, (London, 1953), pp. 354-5.

<sup>35</sup> Michael Hatt, Martina Droth, and Jason Edwards, 'Sculpture Victorious', in Martina Droth, Jason Edwards, and Michael Hatt (eds.), *Sculpture Victorious: art in an age of invention, 1837-1901*, (Yale, 2014), pp. 15-55, 30-4.

<sup>36</sup> Charles Smith in, Gunnis, *Dictionary*, p. 355.

<sup>37</sup> Gunnis, *Dictionary*, p. 355.

<sup>38</sup> Oxford University Museum of Natural History (OUM), Papers of William Smith (SMITH), Box 44, Ms. Journal, 'Journal of William Smith LL. D., Geologist, Civil Engineer, and Mineral Surveyor, on a tour of observation on the principal Freestone quarries in England & Scotland, in company with Mr. Barry the Architect, Mr. De la Beche, and Mr. C. H. Smith, for the purpose of find stone best calculated for the construction of the new Houses of Parliament', (18 Aug. to 23 Oct.), pp. 1-9.

commissioners visited Oxford, Cheltenham, Gloucester, Bristol, Bath, Glastonbury, Dorchester, the Isle of Portland, and Salisbury.<sup>39</sup> **(Image 6)**

During the tour Charles Smith kept a detailed account of his daily work. At Newcastle he examined stone in a quarry which ‘rapidly destroys the cutting edge’ of workman’s tools so quickly that the quarry’s grind-stone was in continual use.<sup>40</sup> In Edinburgh he observed a fine grained siliceous sandstone employed in the city’s Royal Institution, but noted it contained minuscule ‘veins of Iron Oxide, Quartz, and small grains of mica’.<sup>41</sup> After inspecting buildings in Edinburgh and Glasgow, he visited the surrounding quarries to examine the beds from which stone was cut. Smith constantly recorded the age of buildings, their state of decay, and source of stone. When there were no records of where stone had been quarried, Smith sought evidence from the physical quality of stone in buildings and compared it to rock in local quarries.

Smith’s work on the tour was hands on, as he used his experience as a stone mason to examine each specimen. At a quarry 2½ miles from Newcastle, Smith noted that he had ‘Worked some of the stone in the quarry, found it very refractory and hard’.<sup>42</sup> He worked a light brown sandstone, ‘too soft for any permanent works’, in the Getherby Moor Quarries, four miles from Richmond.<sup>43</sup> At the Hookstone Quarry near Harrogate, Smith handled a whitish sandstone with brown iron stains, which he assessed to be ‘an expensive stone to work, probably 50 per cent more than Portland’.<sup>44</sup> Smith recorded details of quarrying techniques at various locations. In the Roche Abbey Quarry, Smith witnessed a stonemason at work cutting a magnesian-limestone. While observing, he jotted down that ‘in the quarry a mason is working, he often sawes the stone to save labor’.<sup>45</sup> At the twelfth-century Southwell Minister Smith was particularly impressed with a magnesian-limestone, known as ‘Bolsover stones’.<sup>46</sup> Smith was so pleased

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<sup>39</sup> Ibid., pp. 11-5.

<sup>40</sup> Royal Institute of British Architects Library, Victoria and Albert Museum, London (RIBA), SmC/1/1, C. H. Smith, notebook entitled ‘Abstracts of notes made by C. H. Smith during his travels with the commissioners in search of stone for the Houses of Parliament in the autumn of the year 1838 and spring of 1839’, p. 1.

<sup>41</sup> Ibid., p. 6.

<sup>42</sup> Ibid., p. 17.

<sup>43</sup> Ibid., p. 25.

<sup>44</sup> Ibid., p. 44.

<sup>45</sup> Ibid., p. 57.

<sup>46</sup> Ibid., p. 81; Smith and George Gilbert Scott later raised doubts as to whether the stone for Southwell was from Bolsover quarry, in W. Cowper, *Westminster New Palace. Return to an order of the Honourable the House of Commons, dated 1*

with Bolsover that after the tour concluded on 5 October 1838, he and the commissioners revisited the stone's quarry in April 1839.<sup>47</sup> As the tour moved South, Smith made contrasting observations at Castle Howard, York Minster, the ruined St Mary's Abbey in York, Oxford, Gloucester, Bath, Bristol, Wells, and Salisbury. Throughout these travels as many quarries and buildings were examined as could be crammed into the hectic schedule. By recording his work in quarries and observations of buildings, Smith produced a notebook which presented a catalogue of information on British stone. Specifically however, his notebook was the collected comments from a stone mason's perspective, with particular attention paid to architectural considerations.

Charles Smith's observations on the qualities of each examined stone for carving and sculpture were published in an 1839 government report.<sup>48</sup> His evidence was presented along with William Smith and De la Beche's geological commentary on each specimen, and thoughts regarding the inspected quarries. Along with Barry, they also published detailed notes on the buildings analysed. De la Beche felt that a chemical study of each stone type would complete the report.<sup>49</sup> On Michael Faraday's (1791-1867) recommendation, De la Beche invited King College London's Professor of Experimental Philosophy, Charles Wheatstone (1802-1875), and the institution's Professor of Chemistry, John Frederic Daniell (1790-1845) to conduct a chemical investigation of the samples.<sup>50</sup> In the new King's College London laboratory, Wheatstone and Daniell performed experiments on the chemical composition and comparative strength of each stone.<sup>51</sup> The results of these tests were included to add chemical evidence to the geological, architectural report. The four commissioners provided the report to justify their selection of Bolsover, a magnesian-limestone from Derbyshire, for the new Parliament. **(Image 7)**

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*August 1861;—for, copy of the report of the committee on the decay of the stone of the new palace at Westminster*, (House of Commons Papers: 1861, no. 504), pp. 26 and 100.

<sup>47</sup> RIBA SmC/1/1, p. 130.

<sup>48</sup> Charles Barry, *Report of the Commissioners appointed to visit the Quarries, and to inquire into the Qualities of the Stone to be used in Building the New Houses of Parliament*, (Houses of Commons, 574, 1839); Charles Barry's hand-written original of this report can be found in the National Archives at Kew (NA) under reference WORK 11/17/5/66.

<sup>49</sup> 'Letter 1115: Henry Thomas De la Beche to Faraday', (5 Nov., 1838), in Frank A. J. L. James (ed.), *The Correspondence of Michael Faraday: Volume 2, 1832-December 1840, Letters 525-1333*, (London, 1993), pp. 528-9, 528.

<sup>50</sup> 'Letter 1120: Faraday to Henry Thomas De la Beche', (16 Nov., 1838), in James (ed.), *The Correspondence of Michael Faraday: Volume 2*, p. 534.

<sup>51</sup> Barry, *Report of the Commissioners appointed to visit the Quarries*, pp. 12-3; S. P. Thompson, 'Wheatstone, Sir Charles (1802–1875)', rev. Brian Bowers, *Oxford Dictionary of National Biography*, Oxford University Press, 2004; online edn, Jan 2011 [<http://ezproxy.ouls.ox.ac.uk:2117/view/article/29184>, accessed 21 July 2013]; Frank A. J. L. James, 'Daniell, John Frederic (1790–1845)', *Oxford Dictionary of National Biography*, Oxford University Press, 2004 [<http://ezproxy.ouls.ox.ac.uk:2117/view/article/7124>, accessed 21 July 2013].

However on discovering that the Bolsover quarry did not have a deep-enough bed of suitable rock to supply Barry's works at Westminster, the commissioners selected Anston, another magnesian-limestone, from Yorkshire, for Parliament.<sup>52</sup> By 1841 around 500 tonnes a month of this stone was being transported via barges and Humber sloops to the banks of the Thames.<sup>53</sup> **(Image 8)** Though a second choice, Anston was a selection which came supported by the commission's extensive report.

Crucially however, this report was published to be referenced in future architectural projects beyond Westminster. Until Edward Hall's 1870 *On the building and ornamental stones of Great Britain and foreign countries*, the report remained the most extensive catalogue of building stones available.<sup>54</sup> Joseph Gwilt, an architect with over forty years' experience of building, published large parts of the report in his 1842 architectural encyclopaedia.<sup>55</sup> This volume was intended to provide guidance to architects on matters of construction. The Parliament stone survey was about building a body of geological knowledge, including chemical evidence, for all architects to employ. For Charles Smith, the tour and subsequent report was an opportunity to demonstrate his own knowledge of working stone and witness the practices of geological observation and collection first-hand.<sup>56</sup> Along with William Smith and De la Beche, two of Britain's foremost men of geology, Charles Smith experienced the process of constructing geological knowledge.

## Practicing Geology

Following the Parliament stone survey, Charles Smith invested a great deal of time acquiring geological knowledge of other building materials. In 1849 he published two articles in *The Builder* continuing the research of the Parliamentary commission on a broader scale. His initial subject was Caen stone, which

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<sup>52</sup> Port, 'Problems of Building in the 1840s', p. 97.

<sup>53</sup> Graham K. Lott and Christine Richardson, 'Yorkshire Stone for building the Houses of Parliament (1839-c.1852)', *Proceedings of the Yorkshire Geological Society*, Vol. 51 (1997), pp. 265-72, 268-9; on transporting the stone, see Christine Richardson, *Yorkshire Stone to London: to create the Houses of Parliament*, (Sheffield, 2007).

<sup>54</sup> Lott, 'The development of the Victorian stone industry', p. 46.

<sup>55</sup> Joseph Gwilt, *An Encyclopaedia of Architecture, Historical, Theoretical, and Practical*, (London, 1842), pp. 457-78; Roger Bowdler, 'Gwilt, Joseph (1784-1863)', *Oxford Dictionary of National Biography*, Oxford University Press, 2004; online edn, Oct 2007 [<http://www.oxforddnb.com/view/article/11811>, accessed 4 Dec 2013].

<sup>56</sup> See Simon J. Knell, *The Culture of English Geology, 1815-1851: a science revealed through its collecting*, (Aldershot, 2000), pp. 22-4.

was a common building choice for architects. Smith's evaluation of Caen stone and the evidence he presented was geological, including some chemical analysis. He began by noting the stone's geographical location, which he identified to be from Yorkshire, south through several counties as far as Dorset, before resurfacing in Normandy around Caen, Bayeux, and Falaise.<sup>57</sup> Charles Smith provided a detailed geological account of the stone, describing how it was,

composed almost entirely of broken shells, occasionally rather oolitic, and containing fragments of very small fossil corals: the whole slightly and irregularly laminated, is united into a mass with a strong calcareous and highly crystalline cement.<sup>58</sup>

It was a stone too coarse grained for minute ornaments, but 'admirably adapted for bold architectural or engineering works'. Smith cited St Stephen's Chapel at Westminster which although recently demolished, was over 500 years old with carvings in an almost perfect state. Charles Barry had deemed the carving above the chapel's cloisters to be so perfectly preserved that he chose to reconstruct it without renovation.

In a second article Smith added details on 'the physical and chemical properties of Caen stone'. Smith produced three tables which displayed what he believed was a complete physical record of various samples of Caen stone.<sup>59</sup> The first table (Fig. 1) presented details from the Museum of Economic Geology's curator, Richard Phillips (1778-1851), whose chemical analysis of Caen samples outlined what he had observed to be the chemical composition of four contrasting examples. The second table outlined the contrasting weights of several Caen samples; when in an ordinary state, when wet, and when completely dry. It included specifications of the amount of fluid each sample was likely to absorb. The information in this table (Fig. 2) was Smith's own research. Finally he included a table which showed how well each sample, when cut into a 2 inch cube, could resist applied pressure. This (Fig.3) specified the applied weight under which each cube had crushed during tests.

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<sup>57</sup> RIBA, SmC/1/2/No. 1, scrapbook of cuttings, C. H. Smith, 'On the Various Qualities of Caen Stone'.

<sup>58</sup> Ibid..

<sup>59</sup> C. H. Smith, 'Experiments, &c., on Caen Stone', *The Builder*, 11 Feb., 1849, Vol. 7, (London), p. 67.

	Gros Banc.	Banc de 4 pieds	Franc Banc.	Outside of St Stephen's Chapel, Westminster.
Carbonate of lime	86.5	86.9	82.5	97.3
Silica	10.5	10.5	13.6	2.0
Alumina	3.0	2.2	3.2	
Oxide of iron	A trace.	0.4	0.7	0.7
Magnesia	A trace.	A trace	....	A very slight trace.

Fig. 1: 'Table A. – Chemical Analysis', by R. Phillips.

	Ordinary state.			Thoroughly wet.			Thoroughly dry.			Weight absorbed.		
	<i>lbs.</i>	<i>oz.</i>	<i>dr.</i>	<i>lbs.</i>	<i>oz.</i>	<i>dr.</i>	<i>lbs.</i>	<i>oz.</i>	<i>dr.</i>	<i>Lbs</i>	<i>oz.</i>	<i>dr.</i>
Gros Banc.	15	4	1	16	14	9	15	2	10	1	11	15
Pierre Franche.	15	8	6	17	2	5	15	7	0	1	11	5
Banc de 4 Pieds.	14	12	1	16	7	14	14	10	1	1	13	13
Pierre de 30 pouces.	16	0	10	17	10	7	15	15	7	1	11	0
Franc Banc.	14	8	4	16	5	14	14	5	12	2	0	2
Ranville.	17	12	12	18	10	5	17	12	5	0	14	0
Aubigny.	18	12	13	19	7	12	18	12	14	0	10	14

Fig. 2: 'Table B. – Weight of 6-inch Cubes', by C. H. Smith

Name of Quarry or Bed.	Pressure on bed.	Pressure on edge.
	<i>Tons.</i>	<i>Tons.</i>
Gros Banc ... Top of block.	3.25	....
" ... Middle do.	....	8.03
" ... Do. do.	5.97	....
" ... Bottom do.	2.97	....
Pierre Franche.	7.18	....
"	....	6.63
Banc de 4 pieds.	2.57	....
"	....	2.38
Pierre de 30 pouces.	3.35	....
"	....	2.67
Franc Banc.	2.10	....
"	....	2.25
Ranville.	6.2	....
"	5.43	....
"	....	5.79
Aubigny.	7.41	....
"	10.78	....
"	....	9.78

Fig. 3: 'Table C. – Experiments upon Cubes of 2-inch Sides, on power to resist crushing', by George Godwin.

Smith's work on Caen stone was of particular importance to architecture in the late 1840s. In December 1848 George Gilbert Scott's (1811-1878) nomination as Surveyor of the Fabric of Westminster Abbey presented the architect with a monumental challenge. Large parts of the medieval Abbey, built of Caen stone, were in rapid decay, as were Christopher Wren's (1632-1723) renovations in poor quality stone from Oxfordshire. By 1852 Scott reported that the Abbey's ancient detail was lost, with both Caen and Oxfordshire stone in complete decay.<sup>60</sup> Scott quickly sought the advice of Smith, whose work on Caen stone and experience as a builder marked him out as a valuable authority for such a problem. Indeed as Scott informed the Abbey's Chapter, Smith was 'a man of extensive knowledge on all subjects bearing upon stone and Building materials ... and is well known as a man of practical science to the Institute of Architects and Engineers'.<sup>61</sup> Scott explained that Smith was an eminent authority, whose work on the Parliamentary stone commission enhanced his reputation in geological questions over stone. Indeed Scott accredited Smith with bringing the importance of the subject of stone decay to the Chapter's attention.<sup>62</sup> When Smith shared his own ideas over how best to preserve stone, Scott agreed that the builder had the answer. Smith had discovered 'a mode of preparing a durable coating', but wanted it subjected 'to the opinion of a few scientific men'. He warned that for all preservation techniques, 'until time and weather had operated upon them, it was impossible to say how they would answer. Nature found out means of decay which the most scientific chemist never thought of'.<sup>63</sup> Nevertheless, Scott believed this suggestion a 'very valuable one' and proposed an investigation similar in structure to that of the Parliamentary inquiry. Scott suggested Smith work alongside Barry, De la Beche, and Faraday to determine the value of the stone coating.<sup>64</sup>

Beyond questions surrounding Caen stone and architectural salvation, Smith endeavoured to produce similar bodies of knowledge for other architectural materials, including the various marbles used at Goldsmith's Hall, with specimens from Corsica, Italy, and Belgium all examined.<sup>65</sup> He paid attention to the effect of smoke on architecture. On this subject, he concluded that the fault lay not with

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<sup>60</sup> G. G. Scott, in Christine Reynolds (ed.), *Surveyors of the fabric of Westminster Abbey, 1827-1906: reports and letters*, (Woodbridge, 2011), p. 37.

<sup>61</sup> Ibid., p. 38.

<sup>62</sup> Ibid., p. 37.

<sup>63</sup> RIBA, SmC/1/2/No. 3, scrapbook of cuttings, C. H. Smith, 'Experiments and Selection of Stones'.

<sup>64</sup> Scott, in Reynolds (ed.), *Surveyors of the fabric of Westminster Abbey*, p. 38.

<sup>65</sup> RIBA, SmC/1/3-4, C. H. Smith, 'Goldsmith's Hall List of Marbles used in the Grand Hall and Staircase', (c.1850).

atmospheres contaminated by coal smoke, but inferior quality building stone. Two blocks which were ‘mineralogically and chemically apparently the same’, might decompose at varying rates in the same atmosphere. This was, Smith believed, not due to air quality, but to the stone bed from which each block had been quarried.<sup>66</sup>

Throughout all of Smith’s work he remained committed to the values of the Parliamentary stone commission. He maintained that to be scientific, architecture should include geological and chemical knowledge of building materials. As Smith surmised,

an architect would require his life and faculties to be prolonged to the extent of the patriarchs of old were he to attempt ... to gain a thorough knowledge of the numerous materials employed in an extensive edifice. The practical part of his profession alone, if scientifically studied, is far too extensive for the brevity of one man’s life.<sup>67</sup>

It was, Smith continued, the ‘duty’ of ‘every member of society to use his best endeavours, however insignificant, - to facilitate the advancement of knowledge’. Architecture involved, aside from knowledge of building and design, geology and chemistry. The short span of man’s life made it desirable to reference authorities in geology and chemistry, or to at least adopt some of their practices.

Smith was adamant that geology be used in architecture and he was explicit about how such knowledge should be produced.<sup>68</sup> He perceived that the great strength of geological and chemical knowledge was that they could be grounded in observable evidence. Considering the Parliamentary stone commission, Smith stipulated that Wheatstone and Daniell’s chemical experiments at King’s College London had invested the final report with great authority, as had the assistance of Buckland and John Phillips.<sup>69</sup> Although such investigations involved chemistry, the knowledge produced contributed to geology. Chemical knowledge of minerals was central to the study of geology. Nevertheless Smith was

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<sup>66</sup> RIBA, SmC/1/2/No. 8, scrapbook of cuttings, C. H. Smith, ‘Effect of Smoke in the destruction of Architecture’.

<sup>67</sup> RIBA, SmC/1/2/No. 1; for the context of architecture as a profession, see J. Mordaunt Crook, ‘The Pre-Victorian Architect: Professionalism & Patronage’, *Architectural History*, Vol. 12 (1969), pp. 62-78, 68.

<sup>68</sup> On science and constructing architectural knowledge, see Carla Yanni, ‘Nature and Nomenclature: William Whewell and the Production of Architectural Knowledge in Early Victorian Britain’, *Architectural History*, Vol. 40 (1997), pp. 204-21.

<sup>69</sup> RIBA, SmC/1/2/No. 3.



sceptical over the prospects of chemistry to prevent stone decay. He doubted that ‘chemical analysis will render much assistance in determining the goodness of a stone for architectural purposes; the most accurate investigation of a chemist will give no certain test either of resistance to atmospheric influences or of rapid disintegration when exposed to weather’.<sup>70</sup> However chemistry was vital in ascertaining the differences between sandstone, limestone, and magnesian-limestone. To determine a stone’s type, and understand its physical character involved chemistry, but the selection of a stone for building with, called for a different kind of experiment.

As Smith saw it, the reason chemical experiment was so ineffectual in predicting a stone’s durability was that time presented a power unrealizable under human control. Smith observed that,

Time is an important element in nature’s operations. What is deficient in power is made up in *time*; and effects are produced during myriads of ages, by powers far too weak to give satisfactory results by any experiments which might be extended over perhaps half a century.<sup>71</sup>

Unlike human experiments, which were conducted under restricted time conditions, nature worked on stone by slow degrees. To produce reliable knowledge for architecture thus involved the observation of stone’s performance in existing structures. As the challenge to an architect’s choice of stone was the risk of decay, and decay was a phenomenon which unfolded gradually, Smith identified that constructing knowledge was a problem of measuring the effects of time. Laboratory experiments were valuable because they produced measurable evidence, but replicating the impact of time in a laboratory was difficult. The Parliament stone commission’s solution to creating such measurable evidence was to observe stone in buildings and then compare its state to uncut stone in quarries. The problem with this method was that it was not always possible to know where stone had originally come from. However to examine a building’s stone in detail, and then analyse rock in quarries for similar qualities, made it possible to identify the original source of stone samples.

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<sup>70</sup> RIBA, SmC/1/2/No. 13, C. H. Smith, ‘On the Varieties of Stone used for Architectural Carving’.

<sup>71</sup> C. H. Smith, ‘Something about a Hod of Mortar’, *The Builder*, 14 Jan., 1865, Vol. 23, (London), pp. 22-4, 22.

Through such comparison, Smith felt geological evidence could be obtained which was measurable and reliable. Ancient structures and quarries were effectively treated as spaces where the results of an experiment, taking hundreds of years to complete, could be observed. Smith supposed that the ability to identify a trustworthy stone required, ‘a man possessing a certain amount of general scientific attainments’, combined with a skill in the ‘handling of the mallet and chisel’. It was a geological task, but chemical and architectural knowledge were included as branches of geology. As Smith concluded, ‘no *mere* chemist, *mere* practical stonemason, nor *mere* anybody else’ could manage the task.<sup>72</sup>

Experiment however was not always appropriate for architecture. Experiment in architecture once built could not rescue a stone poorly chosen. While Smith believed Barry had taken care to select only the best Portland stone for the Reform Club in 1837, he worried that there ‘seemed to have been a mania, of late years, for architects to use soft stone, and spend large sums of money to preserve it from decay’.<sup>73</sup> **(Image 9)** Smith was keen to specify that what was often proclaimed as geological knowledge was unreliable if not produced in an appropriate manner. For example, he drew attention to those who suggested that knowledge of how a stone laid in the earth could explain its rate of decay. ‘To attribute a stone’s poor performance in a building to it being placed at a different angle to that at which it was cut from its natural bed was, Smith asserted, gross speculation.’<sup>74</sup> Smith professed that despite serving many years as a stonemason, he was unable to tell how a stone laid in its quarry once it had been removed to a building site. While he might concede it was possible with some sandstones, he doubted any ‘*practised eyes*’ could really detect the ‘*bed-way*’ of a stone once it had been cut. Such claims were, he warned, badly informed and though professing to employ knowledge of geology, far from scientific.<sup>75</sup> They were grounded not in experiment or observation, but conjecture.

If Smith was confident he knew how to create geological knowledge for architecture, he was equally sure of why it was important that architecture became more scientific and paid greater attention to geology. The Parliamentary stone commission had been more than instructive for Smith; it had provided

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<sup>72</sup> RIBA, SmC/1/2/No. 6, C. H. Smith, ‘The Stone of the New Houses of Parliament’; compare Smith’s emphasis on handling a chisel to examine stone, with questions surrounding the division of labour between sculptors and skilled workers in this period, in Hatt, Droth, and Edwards, ‘Sculpture Victorious’, pp. 26-7.

<sup>73</sup> RIBA, SmC/1/2/No. 3.

<sup>74</sup> RIBA, SmC/1/2/No. 5, C. H. Smith, ‘The “Bed-Way” of building-stone’.

<sup>75</sup> Ibid..

a warning against the use of poorly chosen building materials. While the four commissioners were in Oxford investigating the stone employed in the University's colleges, Smith had witnessed a bleak lesson in what he perceived to be the alternative to using geological knowledge to select stone. Smith examined the quadrangle of All Souls College, where he observed a shelly oolite much in decay, which peeled off in sheets when tampered with.<sup>76</sup> Smith recorded a similar state in the cloisters of New College and the quadrangles of 'Brazen Nose College'. At Christ's Church College, the buildings erected in Queen Anne's reign were equally decayed, leading Smith to conclude that the architect Wren lacked judgement in choosing stone.<sup>77</sup>

At the end of his time in Oxford, Smith surmised that the generally poor state of building surfaces in the city arose 'solely from the use of Heddington stone, brought from about 1½ mile distant'.<sup>78</sup> This shelly oolite had not, Smith continued, been a scientific choice, but one of economy. It was quarried locally and soft to carve. During the eighteenth century, most Oxford colleges had employed this stone, however by the nineteenth century the rock was widely considered to be untrustworthy. By the middle of the century architects working in the city were favouring Bath stone, which was used, among other works, for Scott's Exeter College Chapel and the University Museum.<sup>79</sup>

**(Image 10)** However when Smith visited Oxford in 1838, he found what he felt to be the ultimate vindication of the role of geology in architecture. No matter how beautiful a building was, if it was built without proper attention to the physical character of its stone, the work was wasted. Smith believed that ignorance of stone would undo the proudest achievements of architecture. As he concluded,

It is in the highest degree lamentable to see such fine feeling for architecture  
displayed on the most fragile stone I have ever beheld; and must, before 50

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<sup>76</sup> RIBA, SmC/1/1, p. 92.

<sup>77</sup> Ibid., pp. 93-4.

<sup>78</sup> Ibid., p. 95.

<sup>79</sup> W. J. Arkell, *Oxford Stone*, (London, 1947), p. 26; on Scott's use of various coloured stone in the chapel's interior, see Geoffrey Tyack, 'Gilbert Scott and the Chapel of Exeter College, Oxford.', *Architectural History*, Vol. 50 (2007), pp. 125-48, 143.

years have passed, be completely obliterated, and Oxford present one common ruin.<sup>80</sup>

## Reading Geology

Though Charles Smith had an interest in geology before the Parliamentary stone commission, in the years following it, he laboured to make architecture a subject inseparable from geological knowledge. Though this is in itself interesting, the significance of Smith's work is more extensive. It shows how in the mid-nineteenth century, geology provided radical approaches for conceptualizing architecture, and more broadly, man's use of building materials. Geology shaped new ways of seeing stone and the land from which it was quarried. In advising architects of the importance of geological knowledge, Smith repeated sentiments expressed in William Buckland's *Geology and Mineralogy* (1837). Buckland had described that if a stranger to the British Isle's traversed the coast of Cornwall, North Devon, Wales, Cumberland and West Scotland, he would conclude that Britain was a thinly populated country, consisting mostly of miners and mountaineers. If a second foreigner was to travel along the south and east coast of England, from the River Exe to the River Tyne, they would assert Britain was industrious, populous and urban, 'maintained by the coal with which the strata of these districts are abundantly interspersed'.<sup>81</sup> Finally, Buckland asserted that a third foreigner, travelling from the coast of Dorset to Yorkshire over the plains of limestone and chalk that lay between, may not see 'a single mountain or mine, or coal-pit, or any important manufactory, and occupied by a population almost exclusively agricultural'.<sup>82</sup> Buckland supposed that if these strangers then met, they would provide contrasting visions of England: one of a nation of barren mountains, another of rich pastures, industry and crowds, and one of a 'great cornfield'.

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<sup>80</sup> RIBA, SmC/1/1, pp. 95-6; in contrast, when building Keble College between 1868 and 1886, Butterfield favoured the use of brick rather than the notorious Headington Stone, see Geoffrey Tyack, 'William Butterfield and Oxford: adapted from a lecture by Geoffrey Tyack', in Geoffrey Tyack and Marjory Szurko (eds.), *William Butterfield and Keble College*, (Oxford, 2002).

<sup>81</sup> RIBA, SmC/1/2/No. 13.

<sup>82</sup> Ibid.; for Buckland's actual account, see William Buckland, *Geology and Mineralogy considered with reference to Natural Theology*, (London, 1837), pp. 1-3.

Smith stated that Buckland's observations were astute, and that the explanation for this variance could be explained by a single 'glance at a geological map'.<sup>83</sup> Smith outlined how the character of the British Isles was determined by strips of rock types which ran through the country from North-East to South-West. It was the 'origin, composition, order, and arrangement of these rocky masses' which formed the 'basis of geological science'.<sup>84</sup> If architects were to truly understand the stone they employed, Smith argued that they had to become acquainted with 'the leading doctrines of geology'. Above all else, that involved an understanding of William Smith's 1815 geological map which initially proposed the geological structure which Charles Smith described.<sup>85</sup> William Smith had himself been confident that geological knowledge of strata had utility for architecture. In detailing the fossils contained in oolite rock, he noted the stratum's quality for producing the 'finest Building Stone in the Island for Gothic and other Architecture which requires nice Workmanship'.<sup>86</sup> Indeed one glance at William Smith's map was enough to support Charles Smith's proposal that stone in England could be found of a similar character to Caen Stone. Caen was not a superior resource of the Northern regions of France, which had to be imported to Britain, but part of a geological stratum which ran through England.

While once man's knowledge of the landscape presented a chaotic world of cliffs, cuttings, sand, and clay, 'amidst all this apparent confusion, geologists have discovered a certain degree of order prevailing'. This was ordered stratification, which Charles Smith believed to be a trustworthy understanding of the earth's structure. The layering of rock types presented immutable laws, 'as in all other of Nature's works'. Smith warned architects who doubted the potential of geology to advance knowledge of stone that though theories of strata and rock formation appeared 'startling' and even 'improbable', they were grounded in evidence. Smith claimed that doubters 'must either give me credit

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<sup>83</sup> RIBA, SmC/1/2/No. 13.

<sup>84</sup> Ibid..

<sup>85</sup> See William Smith, *A delineation of the strata of England and Wales: with part of Scotland; exhibiting the collieries and mines, the marshes and fen land originally overflowed by the sea, and the varieties of soil according to the variations in the substrata, illustrated by the most descriptive names*, (London, 1815); compare Charles Smith's advice to George Wilkinson's recommendation that architects acquaint themselves with Lyell, Phillips, De la Beche, and Buckland, in George Wilkinson, *Practical Geology and Ancient Architecture of Ireland*, (London, 1845), p. 11.

<sup>86</sup> William Smith, *Stratigraphical System of organised Fossils, with reference to the specimens of the original geological collection in the British Museum: explaining their state of preservation and their use in identifying the British Strata*, (London, 1817), attached table.

for advancing nothing but what is now admitted by men of science, as an established truth, or they must take the trouble to investigate the subject for themselves'.<sup>87</sup>

Smith was sure that it was probable that, 'the entire materials of the great globe we inhabit, were at one time in a fluid state; and that the cause of this fluidity was heat'.<sup>88</sup> The first of these fluids to cool were the crystalline rocks, especially granites. The varying rates of cooling created differing stones. Crystalline, or igneous, rocks had formed first, before sedimentary and volcanic types. Heat and pressure turned limestone into marble and clay into slate. Smith observed that this 'hypothesis is now admitted by the common consent of nearly all modern geologists and chemists'. The solid earth provided 'a large collection of authentic records' which revealed a narrative of the past. Granite was the oldest and hardest of rock types, and as it was at the foundation of the earth's strata, it was also appropriate for the foundations of architecture.<sup>89</sup> For a fine example of granites endurance and ability to defy the elements, Smith advised readers to witness Dartmoor Prison at Princetown, which was built of a granite with the most remarkably large white crystals. **(Image 11)**

It was because of this early cooling and place at the foundation of all strata, that granite was so hard. It was rich in quartz, which was 'one of the hardest substances in nature'. Likewise, Smith explained that it was quartz that made sandstone resist decay. Most abundant of all building stone was limestone, which was geologically determined to be 'Fish shells, corals of all kinds, and the remains of crustaceous animals, altered and modified in a thousand different ways, in the great laboratory of nature'. Such calcareous rocks formed 'about an eighth part of the external crust of the globe'.<sup>90</sup> As for magnesian-limestone, of which the Houses of Parliament had been built, without a chemical test some varieties might be mistaken for 'soft Portland stone'. This rock was hard, but practical to carve.

Geology transformed man's conception of the earth and landscape from what was 'in ruder times, degraded by the misapplied title of "chaos"', into one of a world ordered for 'the wisest purpose'.<sup>91</sup> The subject reconceived nature as a 'laboratory' and rock as a product of processes unfolding over vast

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<sup>87</sup> RIBA, SmC/1/2/No. 13.

<sup>88</sup> Ibid..

<sup>89</sup> Ibid..

<sup>90</sup> Ibid..

<sup>91</sup> Ibid..

expanses of time. Although his own religion is not recorded, Smith agreed that geology's potential to reveal the order of the earth's strata also revealed evidence of God's design of the universe. 'The ordered structure of the earth demonstrated 'such wonders of Almighty power'.<sup>92</sup> Smith observed that there was nothing 'more evident to geologists than a perpetual series of alterations; there can be discovered no vestige of a beginning, no prospect of an end'.<sup>93</sup>

Smith's writings demonstrate that while he constructed new knowledge through geological practices experienced on the Parliament stone survey, his projection of geology's role in architecture was grounded in detailed readings of the latest geological texts. He was acquainted with William Smith and Buckland's volumes, and interpreted their understandings of the earth's form and structure within proposals for advancing the practice of architecture. Charles Smith's conception that geology revealed natural order, subject to physical laws, echoed William Buckland's sentiments.<sup>94</sup> For Buckland, the pursuit of geological knowledge was a religious quest involving the study of the time preceding man's existence.<sup>95</sup> Curiously, Buckland looked to architecture for a metaphor of how to build the science. Geology was a body of knowledge which would have to be constructed as if to an architectural plan, consisting of several stories. However Buckland stipulated that the edifice would only be complete when geology was fully reconciled with cosmology. 'This would add a 'roof' and 'pinnacles' to the 'perfect building'.<sup>96</sup> That Smith was happy to align himself with Buckland's Anglian teachings at a time when geology was so controversial is revealing. Here was a stone mason and builder eager to understand the materials of his trade from a theological, as well as scientific, perspective.

While Smith accepted Buckland's work, including its religious sentiments, his writings also suggest an openness to the theories of geologist Charles Lyell. Smith supposed that the study of geological processes changed how architects should view the land they built on. Smith agreed that there was 'strong reason to believe that volcanoes and earthquakes are the operations of a power which is everywhere present beneath the ground'.<sup>97</sup> **(Image 12)** Smith continued, observing that, 'We are apt to

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<sup>92</sup> Ibid..

<sup>93</sup> Ibid..

<sup>94</sup> Buckland, *Geology and Mineralogy*, p. 6.

<sup>95</sup> Adelene Buckland, *Novel Science: fiction and the invention of nineteenth-century significant*, (Chicago, 2013), pp. 97 and 100.

<sup>96</sup> Ibid., pp. 101-2.

<sup>97</sup> RIBA, SmC/1/2/No. 13.

regard the earthly foundation, on which the architect raises an edifice, as a specimen of duration and stability'. However he warned that this was naïve when there was so much evidence of violent past geological disturbances.<sup>98</sup> Recent understandings of the geological processes at work on the earth shaped more than observations over what made a stone durable. They involved new ways of conceptualizing stone itself. Geology taught that all hard materials in the world were, in effect, cements. Each solid subject presented 'evidence of having previously been in a fluid or soft state ... chemistry recognises nothing unchangeably solid, liquid, or aeriform'.<sup>99</sup> According to analysis of 'the chemist of geology', all stone was 'natural cement', including that of St Paul's Cathedral and the Roman Colosseum. Stone was, like cement, formed through cohesive or caloric forces. Cohesion was a physical law, 'employed by nature in holding the particles of matter together'.

The mixture of lime and sand to form man-made cement was therefore a way of understanding and imitating nature's works.<sup>100</sup> Although this practice was central to building, cement remained of inferior strength to stone. Smith lamented that 'the most learned philosophers are not able to imitate, nor to compose, even approximately, a cement possessing similar qualities of hardness and durability'.<sup>101</sup> Yet Smith felt geological learning could enhance knowledge of cements. Lyell taught that rock formed through pressure or heat.<sup>102</sup> Smith reiterated this for his architectural readership, explaining how cements 'in a natural state, as rocks and stones, or produced artificially by man', were formed by the same physical laws of cohesion or heat.<sup>103</sup> Understanding geological processes of rock formation shaped new ways of seeing both stone and cement. By treating the two as subject to similar physical laws, Smith declared the creation of a man-made cement of equal hardness and durability to nature's cement as a challenge which might one day be achieved. However the production of such a cement was, he believed, the work of philosophers, labouring to construct geological and chemical knowledge.

Smith claimed that in this age of 'chemistry and geology', it was wrong for 'architects and engineers' to use inferior cements, either naturally made stone, or humanly produced mortar. He cited an

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<sup>98</sup> Ibid..

<sup>99</sup> Smith, 'Something about a Hod of Mortar', p. 22.

<sup>100</sup> Ibid., p. 22.

<sup>101</sup> Ibid., p. 22.

<sup>102</sup> Lyell, *Elements of Geology*, pp. 78-9.

<sup>103</sup> Smith, 'Something about a Hod of Mortar', p. 22.



ancient example to demonstrate this sentiment. One of the most venerated bases for cement among architects was the volcanic dust thrown out of Mt Vesuvius during its eruptions. Vitruvius and Pliny alluded to the powder of puteolanus, or puzzolana, as a powerful natural brick-dust.<sup>104</sup> It was a clay, altered ‘by volcanic agency’. Smith observed how the dust made a cement which resisted the atmosphere and hardened in water. Lyell had previously recorded that the Romans employed the material to construct the foundations of buildings in the sea because of this property.<sup>105</sup> Through the ages, the dust which had buried Pompeii secured ‘great repute with architects and engineers’. Yet Smith believed that there was nothing unique about the cement produced from the dust. Some puzzolana from Vesuvius was imported for use in the government’s construction of a breakwater at Portland between 1844 and 1872 for the Royal Navy.<sup>106</sup> **(Image 13)** Smith examined some of this dust and found little to commend its use. He concluded that employing dust produced through volcanic activity for cement might imitate nature, but to produce a building material as durable as stone required enhanced geological knowledge. Previous geological works had, however, shown the processes which could produce stone, or natural cement.

Smith reckoned that this exchange of geological and architectural knowledge would have improving results for the use of building materials. Smith’s observations and comments echoed the arguments and language Lyell employed in promoting geology as the study of active phenomena. Lyell defined geology as the study of minerals and rock, but also of the successive changes at work on the earth’s surface and interior.<sup>107</sup> Lyell shared in the description of rock as cement. It was formed through ‘cementing processes’, either instantaneously or over vast expanses of time.<sup>108</sup> When explaining the ‘cementing action’ which created sandy oolite stone, Lyell noted that if fragments of sandy stone were plunged into ‘dilute muriatic or other acid, we see them immediately changed into common sand and mud; the cement of lime derived from the shells, having been dissolved by the acid’.<sup>109</sup> Fossilized matter and sand comprising stone was but a chemical process away from being fluid cement. Indeed while Smith used geology to explain architectural materials, Lyell invoked architecture to illustrate geological

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<sup>104</sup> Ibid., p. 23.

<sup>105</sup> Lyell, *Elements of Geology*, pp. 75-6.

<sup>106</sup> Smith, ‘Something about a Hod of Mortar’, p. 23.

<sup>107</sup> Lyell, *Elements of Geology*, p. 2.

<sup>108</sup> Ibid., p. 72.

<sup>109</sup> Ibid., p. 73.

processes. Strata formed when natural cements dried into land. This idea that rock hardened as it dried was, Lyell stipulated, well known in architectural circles. He observed that, 'the greater number of stones used for building and road-making are much softer when first taken from the quarry than after they have been long exposed to the air'.<sup>110</sup> He asserted that architects knew it was best to shape stone when soft and wet, before it lost its 'quarry-water'. The practices of cutting stone and building had geological lessons regarding the effects of time in the earth's strata.

### **Conclusion: the materials of architecture**

Charles Smith's significance in the world of Victorian architecture was considerable. Although he was not alone in trying to make architecture scientific, he was unusual in that he was a builder and practical stone mason, rather than an architect. Having a practical experience of manually working stone, and combining this with scientific learning, made Smith an influential authority. His work was readily available in *The Builder*, while his contributions to the Parliamentary stone commission were published in Gwilt's 1842 architectural encyclopaedia. What is more, his advice was respected and pursued. After consulting Smith regarding the decay at Westminster Abbey, Scott spent over a decade following Smith's proposals. In May 1853 Scott repaired three buttresses with Smith's coating. This work continued throughout the decade, with Scott reporting on the success of Smith's remedy in salvaging 'the very finest things in the kingdom'.<sup>111</sup> In 1859 Scott observed that before applying Smith's solution, much of the stonework was 'so tender that the gentlest touch would brush away the lingering remnants of its ancient surface', but that once coated the stone became 'hard and rigid' with the 'decay arrested'.<sup>112</sup> Scott persisted with this technique throughout the 1860s and 1870s, claiming as late as in 1876 that Smith's 'hardening process' had been '*the saving of the Abbey*'.<sup>113</sup>

Even when Parliament's magnesian-limestone from the Anston quarry, which Smith recommended, performed poorly, Smith's advice was valued. In 1861 a government appointed to inquire

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<sup>110</sup> Ibid., p. 74.

<sup>111</sup> Scott, in Reynolds (ed.), *Surveyors of the fabric of Westminster Abbey*, pp. 40 and 46.

<sup>112</sup> Ibid., p. 47.

<sup>113</sup> Ibid., p. 104.

into the decay of Parliament's stone concluded that magnesian-limestone was 'an undesirable and unsafe material for the construction of public buildings' in London.<sup>114</sup> The inquiry advised that, contrary to Smith's recommendation, Portland stone be the choice for all future government works as this had a superior 'power of resisting the influences of the London atmosphere'. Although the 1861 inquiry rejected Smith's magnesian-limestone, it embraced his attention to geology. With the Director General of the Geological Survey of Great Britain, Roderick Murchison, in the chair, and architects George Gilbert Scott and Edward Middleton Barry, Charles Barry's son, conducting the investigation, the commission displayed a commitment to employing geology in architecture. Along with Portland, they advised all future selections of stone be made in reference to geological and chemical knowledge.<sup>115</sup> Smith not only sat on this committee as a commissioner, but was called as a witness. He claimed that he had recommended Anston to Barry and De la Beche.<sup>116</sup> Smith recalled that they agreed that he should personally inspect the stone used in Parliament's superstructure, but that Barry and the Office of Works had never resolved who should pay his annual fee of £150 for two to three visits a week.<sup>117</sup> As a result, while much of Parliament's stone was 'of a very durable nature', the absence of a mason of practical experience and geological knowledge to inspect the quality of the stone unloaded at Westminster, allowed some sections to be built of inferior quality Anston.<sup>118</sup> The cost of getting the choice of stone wrong is still being realized today, with 2015 estimates for renovation, including restoration of the Palace's stonework, ranging from £3.9 billion and £7.1 billion.<sup>119</sup> However the extent of the failure of Parliament's stone, which was already apparent in the 1850s and 1860s, did little to undermine Smith's reputation. While Scott pursued his advice at Westminster Abbey, the government remained happy to seek his advice at Parliament.

Smith presents a unique insight into how the relationship between Victorian architecture and the world of science unfolded through interactions between architect and builder. As a stone mason and builder, Smith possessed valuable knowledge of architecture's fundamental material. Examining how

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<sup>114</sup> W. Cowper, *Westminster New Palace. Return to an order of the Honourable the House of Commons, dated 1 August 1861;--for, copy of the report of the committee on the decay of the stone of the new palace at Westminster*, (House of Commons Papers: 1861, no. 504), p. viii.

<sup>115</sup> *Ibid.*, p. ix.

<sup>116</sup> *Ibid.*, p. 25.

<sup>117</sup> *Ibid.*, p. 25.

<sup>118</sup> *Ibid.*, p. ix.

<sup>119</sup> <http://www.bbc.co.uk/news/uk-politics-33184160>.

stone was understood in nineteenth-century Britain opens up new insights into the relationship between the knowledge and materials behind the expansion of the human built environment. With the recent attention paid to material culture in history, architectural historians could do worse than pay greater attention to the materials of building. For architectural historians to engage with this ‘material turn’ and avoid a dualism between ideas and material culture, greater attention must be paid to the practical aspects of building, and this almost inevitably involves increased analysis of the materials of architecture.<sup>120</sup> Hopefully this article has gone some way to showing the fruitfulness of moving architectural history beyond questions of style and architectural design, and looking at the practical work of builders and their engagement with materials. To suggest that architectural history requires a material turn is egregious; its very nature is to study the relationship between people and objects. Yet a greater appreciation that buildings are more than collections of symbolic ideas and stylistic concerns would be advantageous. Buildings do embody ideas and cultural values, but they are also intricate networks of manual skills and hard-worked materials.

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<sup>120</sup> Dan Hicks, ‘The material-cultural turn: event and effect’, in Dan Hicks and Mary C. Beaudry (eds.), *The Oxford Handbook of Material Culture Studies*, (Oxford, 2010), pp. 25-98, 29; Ann Brower Stahl, ‘Material Histories’, in Hicks and Beaudry (eds.), *The Oxford Handbook of Material Culture Studies*, pp. 150-72, 151.